

Soil Nitrogen and Carbon Management, Crop Year 2001

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Introduction

An important component for predicting nitrogen (N) application needs (regardless of productivity level) is to estimate the soil capacity to supply plant-available N each year corn is grown. Differences in N supply between fields have been difficult to predict and are often underestimated when N applications are made to production fields. In a general sense, differences are incorporated into N recommendation systems (for example crop rotation effects and adjustments). However, for improving prediction of corn N needs, and especially avoidance of over application and environmental consequences, knowing if and how much response may occur in a field is highly desirable. This would be particularly useful to producers if known ahead of preplant N applications. This is important in situations where little to no supplemental N is required and where rates based solely on yield may direct more N application than the system needs.

Tests that measure soil nitrate as a means to estimate available N have been available for some time, such as the presidedress soil nitrate test. But producers desire alternative methods that are not based solely on nitrate, and that can be utilized before planting. An example of such a test would be one that estimates mineralization of specific soil organic-N fractions. It is also important to conduct research in high-yield environments (where corn uses large amounts of N) so concerns about limiting corn yield potential or negatively impacting soil can be documented or allayed.

Nitrogen management and cropping system history (tillage and crop rotation) have direct impacts on soil organic N and carbon (C) pools, and the tie between soil organic N and C. Soil organic C levels have important implications for organic N retention/release and carbon dioxide (CO₂) fluxes. Specific organic-N pools in soil can be an important source of plant-available N. Nitrogen availability in the soil environment also plays a significant role in determining soil C status, as it is an essential nutrient for microbial metabolism. Nitrogen availability, through influence on yield, will also affect the quantity and quality of plant residue available as a source of soil C. The integral tie between soil organic N and C should be incorporated into the study of crop N requirements and determination of impacts from historical N use, tillage, and crop rotation.

Soil C storage is a long-term process. However, short-term changes in soil C status due to N and soil management can be estimated by monitoring the impact of N and soil management on CO₂ flux. Long-term changes in soil C are indicators of soil potential for storing C and the impact of management on that potential. However, immediate relationships and short-term changes in soil C can be developed through changes in CO₂ emission by monitoring the impact of different N rates on CO₂ flux during the growing season. The maintenance of organic matter can help prevent soil degradation. Soil, as an open system, can play an important role in regulating greenhouse emissions to the atmosphere. Since changes in agricultural practices, like N use, can influence the

soil organic C storage in, and greenhouse gas fluxes from soils, the net benefit due to changing agricultural practices needs to be considered.

Nitrogen use rate is an important consideration for soil C retention and potential nitrate movement to water systems. If farmer use practices are not consistent with recommended N and C management practices, then work as proposed in this project can help farmers predict appropriate field-specific N rates and C management practices. With research being conducted locally and availability of tools for individual site assessments, then producer confidence should improve that productivity can be maintained if a production practice is changed.

Objectives

The objectives of this project are twofold. One is to demonstrate corn N fertilization needs and the short- and long-term N–C relationships across diverse soils, productivity, and crop management systems. The second is to demonstrate the potential of a new soil N test, the Illinois N Soil Test (based on a readily mineralizable organic-N fraction – amino sugar-N), as a predictor of soil N supply, corn response to applied N, and for the adjustment of corn N fertilization rate.

Field Demonstration Description

The strategy for this project is to conduct on-farm field demonstrations with concurrent data collection at approximately ten field sites yearly that encompass a range of soil characteristics, tillage, yield potentials, and N use and N source histories. A history of N application, manure use, tillage, rotation, and crop yield for each site is obtained from the cooperating producer.

Multiple rates of N are applied shortly after corn planting in replicated treatments. Application areas reflect standard field protocols and producer equipment. Normal producer crop management practices are used for the geographic area the site represents (such as tillage, adapted hybrids and pest control). Producers apply no N to the demonstration site, except for starter or incidental N with phosphate fertilizer. Soil pH and other soil nutrients are maintained by application of lime and fertilizers as needed.

Multiple sampling and analyses are conducted to measure site characteristics and N responsiveness: routine soil tests, soil N tests, plant N status, and corn grain yield. Additional soil samples from various depths in the fall, spring, and sidedress are collected to determine the potential viability and sampling protocol of the new Illinois N Soil Test. Soil is sampled by depth increments before N application to measure soil organic and inorganic C, to measure particulate organic matter, and to provide baseline soil C and estimated bulk density. Carbon dioxide flux is monitored at selected sites and selected N rates during the growing season, after harvest, and in the following soybean crop. After harvest plant residue is collected and analyzed for total N and C.

Field Activity

This project began in the spring of 2001. The field sites for 2001 were chosen on criteria of corn after soybean, no manure or primary fertilizer N applied in the fall of 2000 or spring of 2001, and a minimum till or no-till system. Cooperators were asked to not apply N or manure to the area

designated for the demonstration site. All other field activities are completed as normal by the cooperator.

Fourteen sites were located for the project in 2001 (Table 1). Seven of the fourteen sites were identified for soil C sampling and analysis (Figure 1). All sites are used for corn N response and soil N testing. The two sites in Shelby County are with the same producer, but have different soils and yield potentials. The two sites in Boone County are in the same field and have the same management practices and history, but the sites are on different soils. Field site information and cropping history is collected from each producer (Table 1).

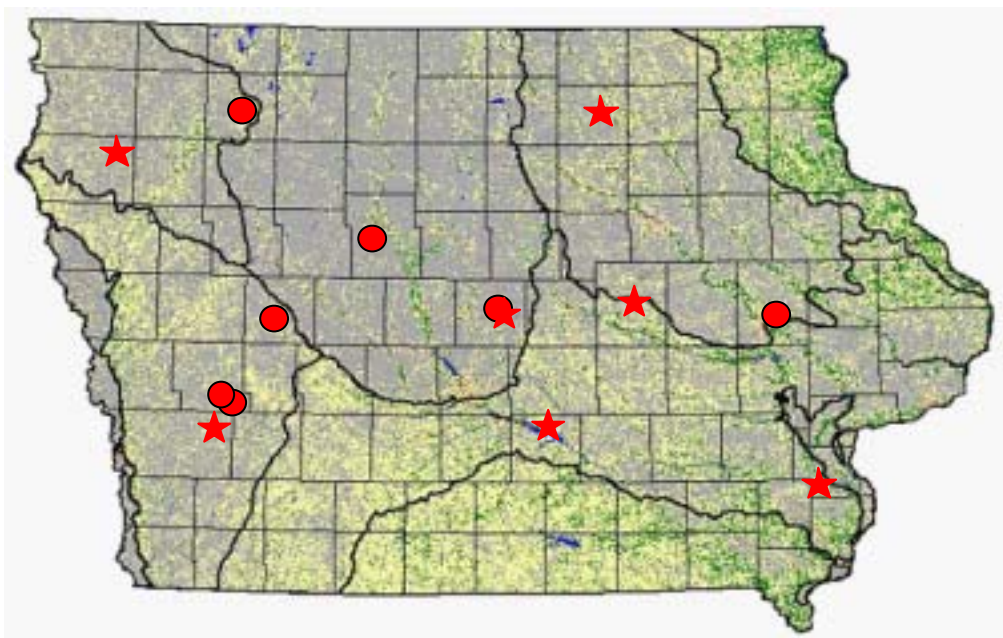


Figure 1. Demonstration sites utilized in 2001. Stars indicate sites identified for C measurements.

Six rates of N (0 to 200 lb N/acre in 40 lb increments) are applied shortly after planting (from planting to V2 growth stage) as surface applied ammonium nitrate. The N rates are replicated four times. No other N is applied except for incidental N in starter or with phosphate fertilizer, which occurred at the Carroll and Shelby-E sites (Table 2).

Each site is soil sampled for routine soil tests, soil N tests, and soil C and N. Sampling for soil N tests includes spring preplant, in-season, and post-harvest. Future years will include fall preplant and weekly temporal sampling at selected sites. Soil is collected at 0-6 inch and 0-12 inch depths. The Illinois N soil test is determined for each sampling and depth. Corn response to N is also monitored through leaf greenness using a Minolta SPAD chlorophyll meter at the R1 (silking) growth stage at all sites. At four contrasting N response sites, post-harvest four-foot profile soil samples are collected for residual nitrate from the 0 and 120 lb N/acre rates.

In order to monitor change in soil C throughout the project life, initial soil samples are collected at 0-2, 2-4, 4-6, 6-12, and 12-24 inch depths. Bulk density is determined at each depth and samples are analyzed for total N and C. Particulate organic matter (POM) is also determined at each site.



Sample Collection for Soil C Analysis, 2001.

After harvest, plant residue is collected, weighed, and analyzed for total N and C. At three sites (Boone-S, Floyd, and Warren) emission of CO₂ is monitored throughout the year at the 0, 80, 160, and 200 lb N/acre rates, and will be monitored in the next soybean crop as well.

Grain yield is determined for each N rate by hand harvest of measured areas, with yields adjusted to 15.5% grain moisture. Seed protein, oil, and starch are determined by near-infrared spectroscopy (NIR) analysis.

As of this reporting date, not all soil and plant analyses have been completed and, therefore, are not reported.

Preliminary 2001 Results

Corn Response to Applied N

Corn grain yield level and yield increase from applied N varied considerably between sites (Table 2 and Figure 2). Site responsiveness to N was calculated as the maximum yield increase from applied N compared to the yield with the zero N rate, and expressed on a percent of the zero N rate yield (Table 2). Overall productivity was high at all sites (average maximum yield of 178 bu/acre), with the grain yield produced with no applied N quite large (average of 153 bu/acre). This documents that with the right conditions, Iowa soils have the capacity to supply large quantities of plant-available N. The measured range in site responsiveness was hoped for the

project as this provides a good data set for evaluation of soil N supply, and for this demonstration project evaluation of the Illinois N Soil Test. The results of that test, however, are not available for this report. Also, best determination of the potential usefulness of that test for Iowa conditions will come after evaluation in multiple crop seasons.

An economic N rate estimate from fitted response curves to applied N at each site (an economic break-even rate at a corn to N price ratio of 10:1) indicates a wide range in economic rates (Table 2 and Figure 2), with three sites having essentially an economic rate of zero lb N/acre and four sites greater than 100 lb N/acre. Generally the need for applied fertilizer N was not high in 2001. This can change substantially between years. At all sites corn was rotated after soybean, which moderates N response. The calculated economic rate is less than the rate to produce maximal yield increase from applied N (Table 2). The overall response to the applied N and shape of the fitted response equation determines the magnitude of difference between the maximal response and economic rate. At some sites where overall yield increase from applied N was low, this difference in rates is large (Floyd and Shelby-E sites for example). A reason for this is that the total magnitude of yield increase to pay for fertilizer N is small; therefore the economic rate is quite lower than the maximal rate.

In some instances the low yield response to applied N related to indicated recent history of N and manure inputs, but not in all cases. To help producers better understand the potential soil supply of plant-available N, corn responsiveness to applied N, and N input needs, then a test like the Illinois N Soil Test may provide valuable information that can improve economics of corn production and reduce potential for nitrate movement to water bodies. Most important will be identification of the non-responsive sites, which the Illinois N Soil Test has shown good potential to do. Also, as producers change N inputs, it will be important to monitor the soil N supply and adjust N fertilization as the supply capability adjusts. This monitoring may be possible with the new amino sugar based soil test.

The corn crop can also be used as an indicator of soil N supply and responsiveness to applied N.



Collecting Minolta SPAD Meter Readings Where No N Was Applied, 2001.

Table 3 lists Minolta SPAD meter readings taken on the ear leaf at approximately the R1 growth stage (silking). The SPAD meter measures the relative leaf greenness, with readings being related to leaf chlorophyll and N concentration. Therefore, this meter provides a non-destructive method to assess the N status of corn during the growing season, and an alternative to leaf or plant sampling and laboratory determination of N concentration. Many variables can affect leaf greenness (examples are hybrid, stress, and growth stage), and this can be noticed in differences between sites at the highest N rate. However, within a site the readings are a good indicator of the N status. Taking readings at silking is an important growth stage timing to determine N stress, but is a little early in the season for determining the final relationship to yield. Most sites with greatest response to applied N had low SPAD readings in the zero N rate check (exceptions are Carroll and Floyd sites). Sites with high check (zero N) rate SPAD values, and little change in SPAD values compared to the maximal N rate, also showed small yield response to applied N. These high zero N rate SPAD values are another indicator of high soil N supply to corn.

Total N and C

Soil samples were collected at multiple depths prior to the application of N fertilizer at seven sites. These samples were air-dried and passed through a 2mm mesh sieve and analyzed for total C and N using a Leco dry combustion system. The results are shown in Table 4. They indicate the large amount of total C and N in soils, and the variation across the state with different soils, with corn soybean rotation, and different management histories. Results show considerable differences in the amount of total C and total N between all sites (Table 4), and the ratio of total C to N (called the C:N ratio). These differences can be attributed to variation between soils and past farming practices. The results also show that total soil C and total N decreases with depth regardless of past history. This trend is typical and can be attributed to soil physical and chemical properties, soil formation, as well as soil management practices.

The C:N ratio of soil organic matter affects microbial activity, microbial use of inorganic N, release of residue N, and overall N availability to plants. Cropping systems greatly influence the amount and type of residue returned to the soil. In conjunction with tillage practices, the amount of soil mixing and aeration impacts microbial activity and speed of C and N release from residue and soil organic-C pools – thus influencing C maintenance in soil and N release to crops. Also, different pools of organic C and N provide more or less crop available inorganic N (through microbial activity) to plants during a growing season. These differences are important to understanding release of soil organic N as plant-available N, and the potential of a soil N test, like the Illinois N Soil Test (which is based on the amino sugar organic-N fraction), to predict differences in soil N availability to corn.

Total soil N declined with soil depth and varied by site (Table 4). However, the large amount of total N in Table 4 is not all plant available. This total amount does not reflect plant-available N because the majority is in organic forms that are not readily available for microbial degradation and conversion to plant-available inorganic N. This process, called mineralization, depends on many factors, including the C:N ratio of the particular organic matter pool. Understanding the differences, and prediction of degradation, is important for C and N management in soils. Past N input history likely influences the size of these pools and, if measurable, can help with prediction of corn N fertilization requirements.

CO₂ Emission

Measuring CO₂ emissions allows investigation of the short-term impact of N application and crop yield on soil C dynamics. During the growing season CO₂ was measured using a CO₂ analyzer (Li-Cor 6200) at three of the seven sites. These measurements were conducted on bi-weekly basis during the growing season and after harvest. Figure 2 shows an example of the accumulated CO₂ measured at the Boone-S site.

The data in Figure 3 represents a calculated accumulation of C loss as CO₂ over time with various rates of N. The CO₂ release was measured at the soil surface to monitor the impact of N rate on microbial activity and the rate of CO₂ release as an indicator of organic matter decomposition. Higher spring N application rates resulted in higher measured CO₂, likely as a result of increased microbial activity, faster decomposition of plant residue and soil organic matter, and enhanced microbial respiration generating a larger amount of CO₂. This indicates that the soil is a dynamic-living system that can be affected by cultural management practices. Many other variables contribute to the release of C as CO₂, including, temperature, soil moisture, soil aeration, soil type, tillage practices, and cropping systems. By comparing these variables, we will be able to determine how N affects CO₂ release or C loss and C dynamics in different soils with different tillage systems across the state. Proper N management is essential in maintaining optimum soil organic matter and is a significant factor in maintaining soil tilth and productivity.

Project Success In 2001

Overall the project met and exceeded expectations for the initial year. There are forty percent more demonstration sites than anticipated; site cooperators are excellent to work with and have high interest in the project; there is a good range in soils, geographic location, productivity, and tillage; every site was successful and expected field work was completed; and the range of results are excellent for meeting the goals of the project. Sample analysis is still underway and data summary and information development continues. Eleven sites are identified for the 2002 season, some cooperators are participating again next year with new sites, and seven sites from 2001 will be monitored in 2002. Soil sampling for the 2002 season began this past fall to assess temporal variation in test results.

Education Component and Outreach Activity

The following outreach activities occurred at the project sites and field days. Field signs indicating the project name, program, and cooperating organizations were located at many sites. Education activities will accelerate as the project develops and results are summarized across multiple years. When the demonstration results are summarized for the first year, project participants and local coordinators will be asked to meet and discuss the results. Information gained from the project will be delivered to farmers, agbusiness, and agency personnel through meetings, conferences, on-going extension education programs and certification programs, fact sheets, newsletters, and web materials. An important educational multiplier will be the extensive use of the project information in extension programs and certification programs. Additional outreach and promotion of the project will occur as results are summarized and reported in various

research farm reports. For the future, as information is learned about the Illinois N Soil Test and the applicability to Iowa corn production, then important impacts to Iowa N use, producer economics, and water quality will come as soil test labs adopt the test method and producers modify N applications.



Figure 4. Field Site Signed for a Field Day and Project Promotion, 2001.

2001 Field Days

Pottawattamie Site: Dr. Mahdi Al-Kaisi presented information and discussed the Soil N and C Management Project at the demonstration site at the ISU Armstrong Research farm during the research farm field day on June 28, 2001. Over 200 people attended the Soil N and C Management Project demonstration site from local communities, which included farmers, general public, agricultural professionals, CCA's, and agency personnel. Handouts were distributed and the audience viewed the demonstration site.

Linn Site: In cooperation with Kirkwood Community College and Iowa State University Extension staff a field day was conducted June 20, 2001. Drs. John Sawyer and Mahdi Al-Kaisi presented information about the IFLM demonstration program objectives and specifics of the Soil N and C Management Project demonstration being conducted at the Kirkwood Community College. Jim Hynek, Agriculture Program Director at Kirkwood, presented data on a N management study conducted by Kirkwood Community College. Local farmers, dealers, CCA's and the general public attended the field day and viewed the demonstration site.

Western Research Farm: A presentation on the Soil N and C Management Project and the overall IFLM program was made by Dr. Mahdi Al-Kaisi during the annual field day of the ISU Western Research Farm in Castana on June 21, 2001. Information was shared concerning the demonstration project, the site locations, and basics of N and C management. Local producers, general public, agricultural professionals, CCA's, and agency personnel attended the field day.

Neely-Kinyon Farm: Dr. Mahdi Al-Kaisi presented information and discussed the Soil N and C Management Project and the overall IFLM program concept during the annual organic farming field day at the ISU Neely-Kinyon Research Farm on August 21, 2001. Information was shared concerning the demonstration project, the site locations, and basics of N and C management. Local producers, general public, agricultural professionals, CCA's, and agency personnel attended the field day.

Tama site: A field day was organized for local farmers by the Tama County Extension office and the area Crop Specialist on August 22, 2001. Two presentations by Drs. John Sawyer and Mahdi Al-Kaisi were made on soil N and C management basics and the objectives of the IFLM program. Dr. Jim Fawcett, area Extension Crop Specialist made a presentation on various integrated pest management topics. There was a tour of the different N applications and discussion of the effects on corn growth and color. The activities included a field tour, producer discussions and questions, and use of visual aids, displays, and handouts.

Southeast Research Farm: A presentation on the Soil N and C Management Project and the overall IFLM program was made by Dr. John Sawyer during the annual field day at the ISU Southeast Research Farm near Crawfordsville on September 6, 2001. Information was shared concerning the demonstration project, the site locations, and basics of N management. Local producers, general public, agricultural professionals, CCA's, and agency personnel attended the field day.

Webster site: A field day for local producers was conducted on September 13, 2001 in cooperation with Iowa Central Community College and Iowa State University Extension county and area staff. Dr. John Sawyer presented information on the IFLM demonstration program objectives, specifics of the Soil N and C Management Project demonstration at the Iowa Central Community College, and basics of N and manure management. In addition to local farmers, dealers, CCA's, students, community college staff, and the general public attended the field day and viewed the demonstration site.

Expected Benefits

Full impact of the project cannot be determined at this time because we are early into the project. However, benefits will eventually include a better understanding of corn N requirements and N-C dynamics across Iowa, and if successful a new soil N test calibrated to Iowa conditions to aid in determination of soil N supply and identification of corn responsiveness to applied N. These benefits will improve producer understanding of corn N needs and setting appropriate N rates, especially when low or no N application is needed (which is the greatest opportunity for environmental and economic improvement related to N management). This should assist producers in maximizing economic corn production and minimizing environmental N impacts.

Nitrogen application and soil management have a significant impact on soil organic matter, and specifically soil C. The loss of C from the soil as CO₂ can impact the environment, soil tilth, soil C pools, and the degradation of soil organic matter. The outcome of this study will further understanding in regard to the interrelationship of N fertilization on short-term C loss and in the long-term maintenance of soil organic C.

Additional Project Partners:

Crop Producers
Iowa State University Extension
Iowa State University Extension Crop Field Specialists
Iowa Natural Resources Conservation Service
Division of Soil Conservation, Iowa Department of Agriculture and Land Stewardship
Agribusiness Association of Iowa
Kirkwood Community College
Iowa Central Community College

Table 1. Site characteristics, management history, and prior crop yields, 2001.

County and Site Name	Soil	Crop Rotation	Nitrogen History ¹ lb N/acre	Manure History	Yield History ²		
					Corn	Soybean	Tillage
					bu/acre		
Boone-N	Nicollet	C-S	140	None	156	45	Minimum-till
Boone-S	Clarion	C-S	140	None	156	45	Minimum-till
Carroll	Marshall	C-S	132	Finishing Swine - last applied in 1996	----	----	Minimum-till
Clay	Primghar, Everly	C-S	130	None	150	52	Minimum-till
Floyd	Clyde	C-S	140	None	165	54	Minimum-till
Linn	Kenyon	C-S	150	Solid Beef - last applied in 1999	160	57	Minimum-till
Louisa	Mahaska, Otley	C-S	135	None	155	47	Minimum-till
Plymouth	Galva	C-S	130	None	156	49	No-till/Row Cultivate
Pottawattamie	Marshall	C-S	150	None	----	----	No-till
Shelby-E	Marshall	C-S	150	None	145	45	Minimum-till
Shelby-W	Zook	C-S	150	None	170	68	Minimum-till
Tama	Tama, Garwin	C-S	170	Dairy Pit - last applied in 2000	159	52	Minimum-till
Warren	Nevin	C-S	150	None	150	50	No-till
Webster	Webster	C-S	----	None	----	----	Minimum-till

¹ Nitrogen application history is for the last two to three corn crops.

² Yield history is average of last two to three crop years.

Table 2. Preliminary 2001 corn grain yield response to applied N.

2001 Site	No-N Check	Economic Response ²		Maximal Response ³		Yield
	Yield ¹	N Rate	Yield	N Rate	Yield	Increase ⁴
	bu/acre	lb N/acre	bu/acre	lb N/acre	bu/acre	%
Boone-N	149	36	172	39	173	16.2
Boone-S	148	103	167	163	170	15.5
Carroll	160	0	158	174	165	3.3
Clay	118	137	181	157	182	54.6
Floyd	158	3	161	169	170	7.6
Linn	200	47	211	65	212	5.8
Louisa	126	73	181	79	181	43.7
Plymouth	150	143	174	200	178	19.0
Pottawattamie	167	31	176	39	176	5.7
Shelby-E	166	0	168	200	177	6.6
Shelby-W	182	38	185	162	191	5.0
Tama	150	38	159	184	166	10.5
Warren	137	102	208	111	209	52.2
Webster	140	82	165	105	166	18.7

¹ Yield with zero applied N.

² Economic N rate and yield at economic rate calculated at a break-even 10:1 corn:nitrogen price ratio (example \$2.00/bu corn and \$0.20/lb N).

³ Nitrogen rate and yield at maximum response to applied N from the fitted response equation.

⁴ The percent yield increase from applied N at the maximal response above the no-N check.

Note: Carroll site had 12 lb N/acre applied at corn planting with starter. Shelby-E site had 13 lb N/acre applied as DAP.

Table 3. Preliminary 2001 Minolta SPAD chlorophyll meter reading (corn ear leaf greenness) response to applied N.

2001 Site	Ear Leaf Greenness ¹		
	No-N Check ²	Economic N Rate ³	Maximum ⁴
----- SPAD Reading -----			
Boone-N	49.1	56.0	61.3
Boone-S	51.0	59.0	60.1
Carroll	50.5	50.5	62.2
Clay	51.9	61.1	61.7
Floyd	49.0	49.0	60.9
Linn	56.0	57.7	60.6
Louisa	41.5	56.2	57.5
Plymouth	45.0	56.6	57.0
Pottawattamie	58.1	60.2	62.9
Shelby-E	59.3	59.3	63.2
Shelby-W	59.8	61.6	65.1
Tama	51.0	55.3	58.0
Warren	47.5	60.5	61.5
Webster	56.5	61.8	63.6

¹ Corn ear leaf greenness readings from a Minolta SPAD chlorophyll meter at the silking (R1) growth stage.

² SPAD reading with zero applied.

³ Interpolated SPAD reading at the economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio (example \$2.00/bu corn and \$0.20/lb N).

⁴ At maximum response to applied N from the fitted response equation.

Table 4. Total soil N and C at different depths before N application, 2001.

Site	Sample Depth (in)														
	0-2			2-4			4-6			6-12			12-24		
	C	N	C/N	C	N	C/N	C	N	C/N	C	N	C/N	C	N	C/N
	----- Total C or N (lb/acre) -----														
Boone	12331	919	13.4	12590	927	13.6	12323	886	13.9	15388	1111	13.9	12125	795	15.3
Floyd	20836	1979	10.5	19365	1897	10.2	19569	1939	10.1	21757	2220	9.8	11967	1402	8.5
Louisa	14693	1099	13.4	13126	994	13.2	11441	860	13.3	11358	815	13.9	8029	528	15.2
Plymouth	14679	1221	12.0	13237	1117	11.8	11560	1053	11.0	13921	1155	12.0	9975	814	12.3
Pottawattamie	13490	1022	13.2	10899	859	12.7	9629	753	12.8	11209	859	13.1	7821	585	13.4
Tama	13368	1164	11.5	10580	959	11.0	8708	826	10.5	7777	775	10.0	5254	515	10.2
Warren	12018	944	12.7	10229	808	12.7	9891	753	13.1	11245	855	13.1	10691	829	12.9

Figure 2. Preliminary corn grain yield response to applied N at each demonstration site, 2001 (economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio).

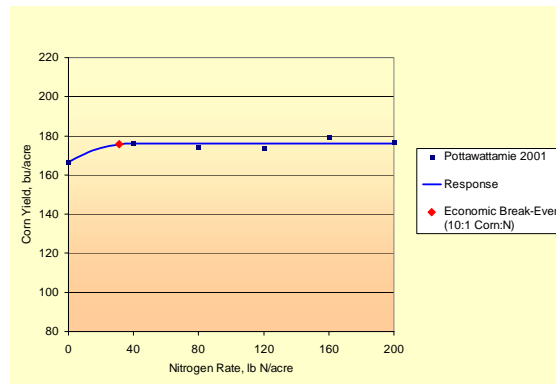
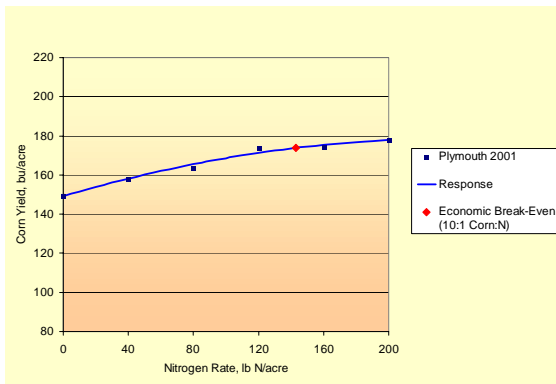
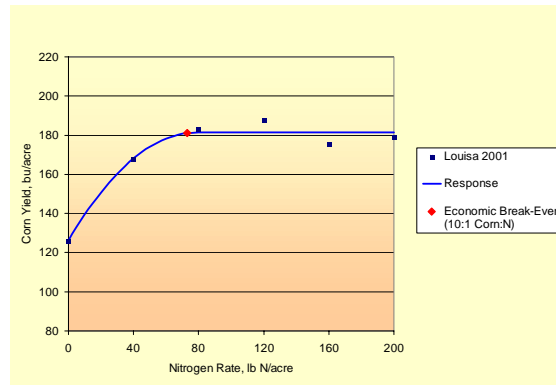
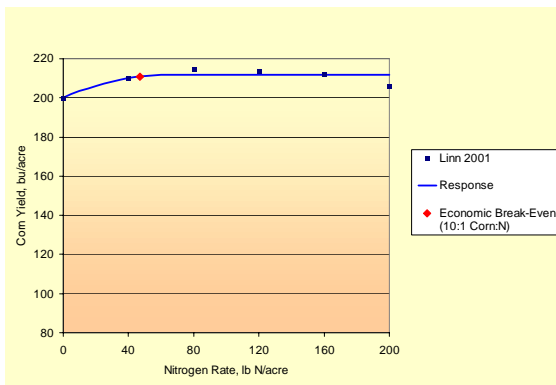
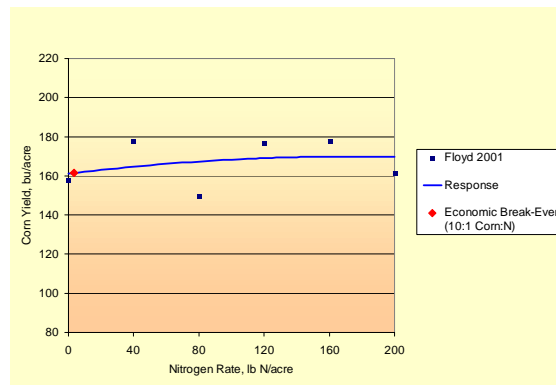
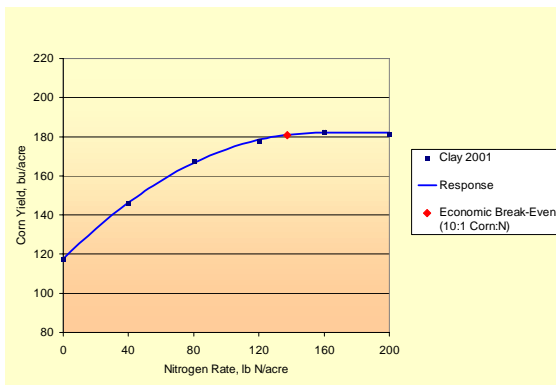
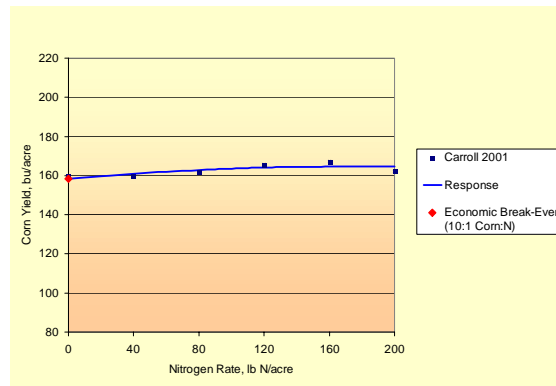
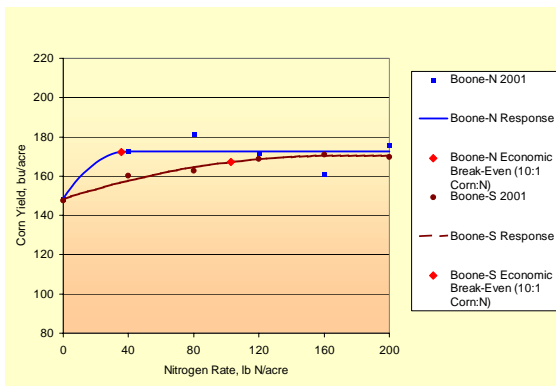


Figure 2 continued. Preliminary corn grain yield response to applied N at each demonstration site, 2001 (economic N rate calculated at a break-even 10:1 corn:nitrogen price ratio).

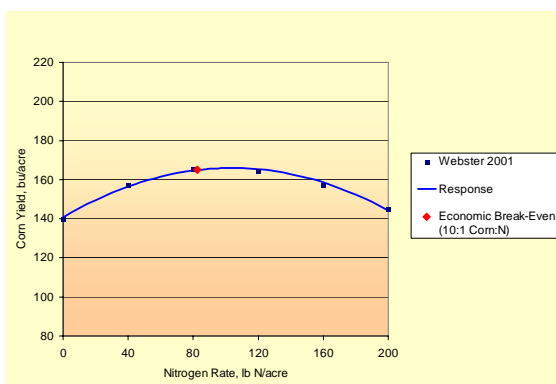
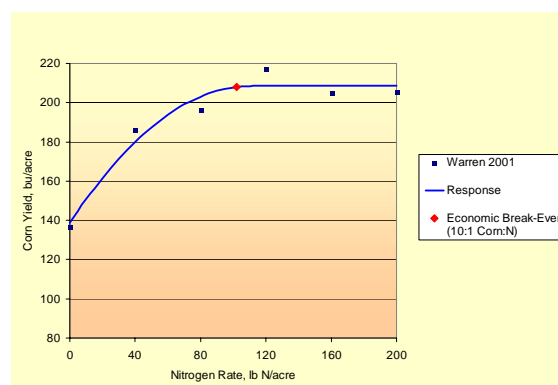
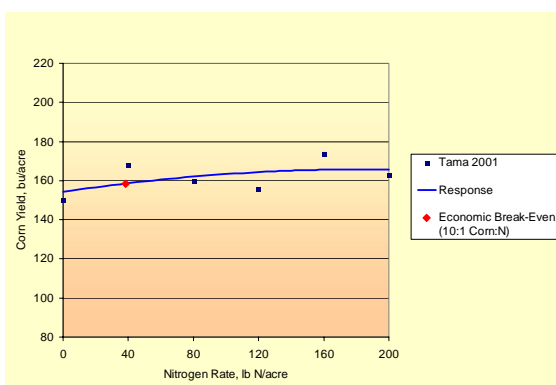
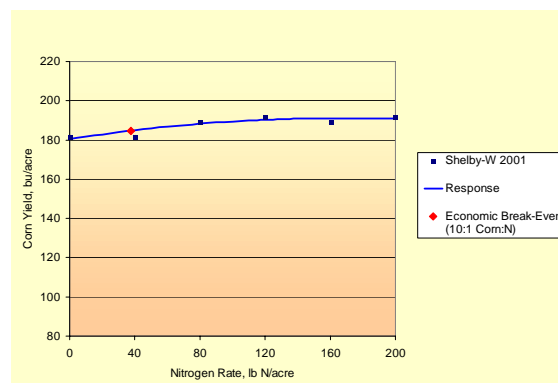
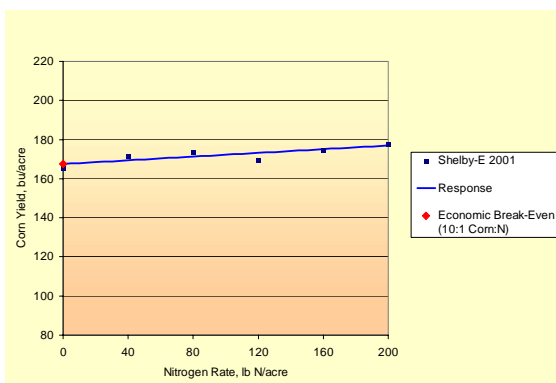


Figure 3. Accumulation of C loss as CO₂ over time at the Boone-S site, 2001. Measurements began on August 9.

